RESEARCH ARTICLE

Diffusion kurtosis imaging in the differential diagnosis of parotid gland disease and parotid adenolymphoma: preliminary results

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Objectives: To study the value of diffusion kurtosis imaging (DKI) in diagnosis of parotid gland disease (PGD) with different pathological patterns and parotid adenolymphoma (PAL).

Methods: 57 patients with different kinds of PGD were enrolled and underwent DKI and conventional diffusion-weighted imaging (DWI). All patients were categorized into different groups according to their pathological patterns. The result of calculating the value of DKI-derived parameters (K_{mean} , K_{rad} , K_{ax} , D_{mean} , D_{rad} , D_{ax} , and FA) and apparent diffusion coefficient (ADC) of DWI were used to study their diagnostic accuracy in PGD with different pathological patterns. The binary logistic regression method was used to confirm clinical valuable diffusion parameters (obtained with DKI and DWI models) for diagnosing PAL. Using MedCalc 13.0, receiver operating characteristic (ROC) analysis was conducted to evaluate the diagnostic value of confirmed parameters based on the logistic regression equation.

Results: Both DKI parameters and conventional ADC showed statistical significance in diagnosing PGD with different pathological patterns ($p < .01$). By using the DKI model, kurtosis coefficients showed higher diagnostic capability than diffusion coefficients ($[K_{\text{mean}} + K_{\text{rad}} + K_{\text{ax}}]$ vs $[D_{\text{mean}} + D_{\text{rad}} + D_{\text{ax}}]$; 22 vs 15, $p < .01$) did in the differential diagnosis among different PGD groups. In the diagnosis of PAL among all PGD patterns, the ROC analysis demonstrated that the area under curve (AUC) FA + K_{ax} [0.881 ± 0.057 (0.824 to 0.938)] is higher than that when using FA [0.629 ± 0.095 (0.534 to 0.724)] and K_{ax} [0.800 ± 0.070 (0.730 to 0.870)] alone ($p < .05$), with sensitivity, specificity, accuracy, and both positive and negative predictive values of 71.43, 95.78, 91.77, 76.92, and 94.44%, respectively.

Conclusions: DKI showed higher diagnostic capacity in the differential diagnosis of PGD with different pathological patterns. Combined parameters of DKI can differentiate PAL from other PGD pathological patterns with a high degree of accuracy. This technique shows great potential for DKI in the differential diagnosis of PGD within a certain pathological category. *Dentomaxillofacial Radiology* (2018) 47, 20170388. doi: [10.1259/dmfr.20170388](https://doi.org/10.1259/dmfr.20170388)

Cite this article as: Yu S, Zhang Z, Bao Q, Su J, Liu M, Shi Q, et al. Diffusion kurtosis imaging in the differential diagnosis of parotid gland disease and parotid adenolymphoma: preliminary results. *Dentomaxillofac Radiol* 2018; 47: 20170388.

Keywords: MRI; parotid gland tumor; diffusion-weighted imaging; diffusion kurtosis imaging

Introduction

Parotid gland disease (PGD), including parotid infective and parotid gland tumor (PGT) lesions, is one of the common clinical diseases in head and neck. It is still difficult to distinguish infectious disease from tumor lesions based on clinical symptoms and conventional MRI

findings. In recent years, advanced MRI techniques, such as the dynamic contrast-enhanced (DCE) MRI¹ and diffusion-weighted imaging (DWI), were applied to differential diagnosis of PGD. Both methods can effectively improve the accuracy of the differential diagnosis of PGD by using both hemodynamic and biochemical information about the tumors. However, because of the limitations of these techniques, their sensitivity and specificity are still low.²⁻⁶

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Received 19 October 2017; revised 26 March 2018; accepted 16 April 2018

DKI is an improved diffusion MRI model that can reflect the non-Gaussian movement of water molecules in biological tissues. The advantages of this technique have been recognized clinically, and it is widely used in the central nervous system.^{7–10} The MRI model reflects both the diffusion movement and microstructural characteristics of the organization of water molecules.^{11–14} More specifically, the kurtosis coefficient shows a strong correlation with the complexity of the microstructure.¹³ In human organization, it is more suitable to quantify the diffusion of water molecules in biological tissues with the theory of non-Gaussian distribution of water molecule movement. DKI is an improved version of DWI technique since it can detect microstructural information noninvasively.^{15,16} The parameters of DKI include the diffusion kurtosis coefficients (K_{mean} , K_{rad} , and K_{ax}), diffusion coefficients (D_{mean} , D_{rad} , and D_{ax}), and fractional anisotropy (FA) value. K_{mean} refers to the average value of diffusion kurtosis in each gradient direction; the more complex the organization structure and the more obvious the limited water molecular diffusion, the greater the value of K_{mean} . K_{rad} refers to the average value of diffusion kurtosis that is perpendicular to the main eigenvector direction. K_{ax} refers to the value of diffusion kurtosis of the main eigenvector direction; when the organization structure is looser, the K_{ax} value is smaller and leads to an isotropic diffusion. By contrast, when the organization structure is tighter, the K_{ax} value is greater that leads to an anisotropic diffusion. D_{mean} is the average value of the diffusion coefficient in multiple directions after having been corrected by using the K value in the DKI imaging model. D_{ax} is the maximum divergent value of the diffusion coefficient in the corrected model, namely, the radial diffusion eigenvalues. D_{rad} is the average value of the diffusion coefficient that is perpendicular to the main eigenvector direction. The FA value of the DKI model is calculated by using the DKI model after correction and is different from the FA value of the traditional diffusion tensor imaging (DTI) model. To the best of our knowledge, the quantitative analysis of DKI in diagnosing PGD has not yet been studied. This study will explore the potentially value of DKI-derived parameters in diagnosis of PGD by using the DKI model.

Methods and materials

General information

The institutional review board of Fujian Provincial Hospital approved this study, and the requirement for patient informed consent was waived due to the retrospective nature of this study. 57 patients with parotid diseases who underwent DKI and DWI from May 2015 to October 2016 at our hospital were retrospectively analyzed. Patients included 37 males and 20 females aged 21 to 86 years old, with a median age of 52 years old. The diagnoses of included patients were: 14 cases of parotid adenolymphoma; 10 cases of infectious disease (2 cases of Kimura's disease, 2 cases of inflammatory lymph node enlargement, 3 cases of cellulitis, 1 case of gill fistula

infection, and 2 cases of Sjögren's syndrome); 19 cases of mixed tumors; 4 cases of other benign tumors (2 cases of basal cell adenoma, 1 case of hemangioma, and 1 case of schwannoma); and 10 cases of malignant tumors (3 cases of mucoepidermoid carcinoma, 2 cases of acinar cell carcinoma, 2 cases of squamous cell carcinoma, 1 case of eosinophilic cell carcinoma, 1 case of mucosal tissue marginal zone B cell lymphoma, and 1 case of original neural ectoderm tumor). 47 cases of parotid gland tumors were pathologically confirmed after surgical resection. The cases of infectious disease including inflammatory lymph node enlargement, Kimura's disease, and gill fistula infection were diagnosed by postoperative pathology and clinical manifestation; the case of cellulitis was diagnosed clinically (clinical symptoms improved after anti-infection treatment), and the case of Sjögren's syndrome was diagnosed clinically. All subjects were divided into the normal parotid gland group (A), infectious lesion group (B), mixed tumor group (C), adenolymphoma group (D), other benign tumor group (E), and malignant tumor group (F).

MRI

A 1.5 T MR scanner (Magnetom Aera, Siemens Healthcare, Erlangen, Germany) with a 20-channel head and neck joint coil was used in this study. Head and neck routine MR examination (T2WI, T1WI, fat suppression-T2WI) was firstly performed and followed by both DWI and DKI sequences. The DWI scanning parameters were TR: 6,800 ms; TE: 82 ms; slice thickness: 4 mm; interlayer spacing: 0; matrix: 192×153 ; FOV: 220×213 mm; b values of 0 and $1,000 \text{ s mm}^{-2}$; NEX: 1; acquisition time: 1 min 57 s. The DKI scanning parameters were TR: 4,000 ms; TE: 93 ms; slice thickness: 4 mm; interlayer spacing: 0; matrix: 128×128 ; FOV: 230×230 mm; NEX: 1; b value of 0, 1,000, and $2,000 \text{ s mm}^{-2}$; diffusion sensitive gradient direction: 30; iPAT factor: 2; acquisition time: 4 min 46 s.

Image post-processing

DKI images were processed using DKE (<http://academicdepartments.musc.edu/cbi/dki/>) software to obtain the kurtosis coefficients (K_{mean} , K_{rad} , and K_{ax}) and the diffusion coefficients (D_{mean} , D_{rad} , D_{ax} , and FA). The apparent diffusion coefficient (ADC) is calculated by using conventional DWI data. Two attending radiologists measured the corresponding parameter values separately with routine T2WI images and T1WI enhanced images as reference. In order to ensure the accuracy of measurement results, three different regions of interest (ROIs) were set up in the solid parts of the lesion that had a uniform signal in an attempt to avoid the area of blood vessels, hemorrhage, necrosis, or cystic degeneration. The ROIs had an area of 0.3 to 0.5 cm^2 and were used to calculate the average as the final measured values.

Statistical analysis

Statistical analysis was carried out using SPSS 22.0 software. All data were analyzed using the Kolmogorov-Smirnov

Table 1 DKI-derived parameters and conventional ADC values among different pathological patterns of PGD

Group	<i>K</i> _{mean}	<i>K</i> _{rad}	<i>K</i> _{ax}	<i>D</i> _{mean} ($\mu\text{m}^2 \text{ms}^{-1}$)	<i>D</i> _{rad} ($\mu\text{m}^2 \text{ms}^{-1}$)	<i>D</i> _{ax} ($\mu\text{m}^2 \text{ms}^{-1}$)	<i>FA</i>	<i>ADC</i> ($\times 10^{-3} \text{mm}^2 \text{s}^{-1}$)
A	0.879 ± 0.069	0.837 ± 0.081	0.910 ± 0.074	1.381 ± 0.161	1.281 ± 0.167	1.570 ± 0.199	0.145 ± 0.026	1.079 ± 0.106
B	0.781 ± 0.071	0.882 ± 0.305	0.826 ± 0.161	1.543 ± 0.258	1.397 ± 0.317	1.682 ± 0.351	0.144 ± 0.042	1.160 ± 0.115
C	0.508 ± 0.085	0.474 ± 0.081	0.554 ± 0.102	1.860 ± 0.620	1.825 ± 0.534	2.085 ± 0.544	0.094 ± 0.031	1.358 ± 0.178
D	0.958 ± 0.186	0.920 ± 0.182	1.035 ± 0.225	1.192 ± 0.333	1.123 ± 0.325	1.263 ± 0.367	0.104 ± 0.049	0.910 ± 0.139
E	0.547 ± 0.047	0.519 ± 0.060	0.578 ± 0.062	2.071 ± 0.2020	1.927 ± 0.187	2.353 ± 0.254	0.134 ± 0.033	1.235 ± 0.142
F	0.860 ± 0.116	0.848 ± 0.121	0.849 ± 0.123	1.300 ± 0.353	1.224 ± 0.339	1.439 ± 0.372	0.127 ± 0.017	0.813 ± 0.066
T	54.278	51.127	52.188	32.141	34.891	38.981	24.160	62.926
<i>p</i> value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

test for normal distribution and Levene's test for homogeneity of variance. The comparison among groups was performed using a Kruskal-Wallis test. If heterogeneity of variance was evident, the comparison between two groups was performed using Tamhane's T_2 test. Binary classification logistic regression was used to select parameters with significant difference in the differential diagnosis of PAL and non-PAL and to analyze the efficiency of the model and to identify PAL and non-PAL. $Y = \log(p/1p)$, where p indicates the probability of the disease for PAL. Finally, a ROC curve was drawn using MedCalc 13.0 software to analyze the diagnostic value of PAL with the parameters after filtering and using the binary classification logistic regression equation. $p < .05$ was considered statistically significant.

Results

Analysis results of different pathological types of PGD

The difference between the traditional ADC value and parameters of DKI in different pathological types of PGD showed statistical significance ($p < .05$) (Table 1). When the

two analyses were compared, the diffusion kurtosis coefficients (K_{mean} , K_{rad} , and K_{ax}) showed significant differences in 22 groups, but the diffusion coefficients (D_{mean} , D_{rad} , and D_{ax}) showed significant difference in only 15 groups. These differences were statistically significant ($p < .01$). The details of the two analyses between the different types of PGD were summarized in Table 2. Different pathological types of PGD showed different DKI parameter values and ADC values (Figure 1). The diffusion kurtosis coefficients (K_{mean} , K_{rad} , and K_{ax}) showed the higher values in the PAL group, the lower values in the group of mixed tumor as well as other benign tumors, and little differences in the normal parotid gland group, infectious disease group, and malignant tumor group. In contrast, the diffusion coefficients (D_{mean} , D_{rad} , and D_{ax}) had the lower values in the PAL group and the higher values in the mixed tumor and other benign tumor group. Additionally, the values in the malignant tumor group were lower than that in both the normal parotid gland group and infectious disease group. The traditional ADC values displayed the same changing trends in the diffusion coefficient parameters of DKI model (Figure 2).

Table 2 DKI-derived parameters and conventional ADC values between subgroups of different pathological patterns of PGD after post hoc analysis

	<i>K</i> _{mean}	<i>K</i> _{rad}	<i>K</i> _{ax}	<i>D</i> _{mean}	<i>D</i> _{rad}	<i>D</i> _{ax}	<i>FA</i>	<i>ADC</i>
A and B	0.055	1.000	0.98	0.832	0.997	0.998	1.000	0.784
A and C	<0.001	<0.001	<0.001	0.056	0.005	0.009	<0.001	<0.001
A and D	0.909	0.879	0.487	0.634	0.836	0.192	0.147	0.013
A and E	<0.001	0.002	0.004	0.051	0.042	0.07	1.000	0.829
A and F	1.000	1.000	0.891	0.999	1.000	0.978	0.231	<0.001
B and C	<0.001	0.054	0.01	0.648	0.193	0.998	0.104	0.026
B and D	0.07	1.000	0.222	0.141	0.607	0.998	0.549	0.002
B and E	0.001	0.102	0.031	0.068	0.058	0.998	1.000	0.999
B and F	0.398	1.000	1.000	0.538	0.966	0.998	0.993	<0.001
C and D	<0.001	<0.001	<0.001	0.006	0.001	<0.001	1.000	<0.001
C and E	0.981	0.987	1.000	0.985	1.000	0.932	0.735	0.959
C and F	<0.001	<0.001	<0.001	0.027	0.004	0.002	0.004	<0.001
D and E	<0.001	<0.001	<0.001	0.002	0.002	0.004	0.963	0.150
D and F	0.783	0.971	0.153	0.999	0.999	0.952	0.826	0.332
E and F	<0.001	<0.001	0.002	0.007	0.007	0.015	1.000	0.114

Figure 1 Boxplots show DKI-derived parameters and conventional ADC values among different pathological patterns of PGD. The differences in the K_{mean} , K_{rad} , and K_{ax} are higher than those of the parameters D_{mean} , D_{rad} , and D_{ax} and the ADC value, indicating close correlations between kurtosis-related parameters (K_{mean} , K_{rad} , K_{ax}) and the tissue microstructure. ADC, apparent diffusion coefficient; PGD, parotid gland disease.

Indicators of DKI to diagnose PAL

The selected DKI parameters, which are filtered by the binary classification logistic regression, showed that the values of K_{ax} ($p < .001$) and FA ($p = .003$) had a higher efficiency in the diagnosis of PAL. The logistic regression equation that was used is as follows: $Y = -6.68 - 41.34 \times \text{FA} + 11.09 \times K_{\text{ax}}$. If $Y > -0.75$, we considered the patient as having PAL. ROC curve analysis showed that the AUC using FA plus K_{ax} [0.881 ± 0.057 (0.824 to 0.938)] for the diagnosis of PAL was higher than that using K_{ax} [0.800 ± 0.070 (0.730 to 0.870)] and FA [0.629 ± 0.095 (0.534 to 0.724)] separately; the corresponding differences were statistically significant ($Z = 1.836$, $p = .0464$; $Z = 2.406$, $p = .0161$; Figure 3). The sensitivity, specificity, accuracy, positive predictive and negative predictive values of FA plus K_{ax} for the diagnosis of PAL were 71.43, 95.78, 91.77, 95.78, and 94.44%, respectively.

Discussion

Present status of the diagnosis of PGD

PGD is a type of common head and neck disease observed clinically, and preoperative imaging is helpful for its qualitative diagnosis. Preoperative reasonable qualitative diagnosis of PGD to distinguish the nature of the lesion is helpful for clinicians to take the reasonable treatment strategies and choose the appropriate surgical procedure. Due to the lack of specific clinical experience, it is difficult to make a preoperative qualitative diagnosis since the different pathological types of PGD may lead to a misdiagnosis. Conventional MRI is one of the main imaging methods in the diagnosis of PGD. Also, conventional MRI uses overlapping signals to determine the nature

of lesions via the position, shape, and characteristics of the lesion's signal strength as the main evaluation index, however, it has the disadvantages of both low sensitivity and specificity. DWI imaging can reflect the diffusion characteristics of water molecules in organization. DTI can not only reflect the diffusion characteristics of water molecules in organization but also reflect the directional characteristic of water molecular diffusion movement in organization. Both DWI and DTI show great application value in the diagnosis and treatment of PGD, but these two models are based on the hypothesis that the movement of water molecules in organization occurs according to a Gaussian form distribution. In fact, the movement of water molecules in organization is a non-Gaussian form distribution. Thus, the clinical application value of both traditional DWI and DTI is limited in certain ways. DKI, which is based on the non-Gaussian distribution of water molecular motion, is expected to provide more valuable information in the diagnosis of PGD.

The parameters of kurtosis (K_{mean} , K_{rad} , and K_{ax}) and diffusion (D_{mean} , D_{rad} , and D_{ax}) obtained from DKI imaging have different changing trends in different types of lesions of the parotid gland (Figure 2). The diffusion of the kurtosis coefficients (K_{mean} , K_{rad} , and K_{ax}) mainly reflect the features of organizational structure,¹⁷ while the diffusion coefficients (D_{mean} , D_{rad} , and D_{ax}) mainly reflect the diffusion of water molecules. This study analyzed the difference of every pairs of different types of parotid gland disease and found that the diffusion kurtosis coefficients (K_{mean} , K_{rad} , and K_{ax}) showed statistical significance 22 times, while the diffusion coefficients (D_{mean} , D_{rad} , and D_{ax}) showed statistical significance 15 times ($p < .05$) (Table 2). The results of this study are consistent with previous research findings that kurtosis parameters

Figure 2 The variation trend of DKI-derived parameters and conventional ADC values among different pathological patterns of PGD. The different variation trends of kurtosis-related parameters and diffusion-related parameters reflected the different information provided by these parameters. ADC, apparent diffusion coefficient; DKI, diffusion kurtosis imaging; PGD, parotid gland disease.

of DKI parameters show higher sensitivity.^{12-14,17} In this study, the diffusion kurtosis coefficients (K_{mean} , K_{rad} , and K_{ax}) are highest in the PAL group because of its histopathological characteristics. PAL is a benign tumor consisting of both epithelial tissue and lymphatic tissue. Some most notable histopathological characteristics of PAL include: epithelial tissue forming irregular ducts and small cysts, hyperplasia of the lymphoid tissue forms lymphoid follicles, interstitial capillaries of tumor cells are rich, the distribution of cells in tumors is dense, the extracellular space is smaller, the distribution of cells in the tumors is dense, and there is less clearance outside the cell. All these histopathological characteristics lead to a higher diffusion kurtosis coefficient value. In addition, this research showed that the diffusion kurtosis coefficients (K_{mean} , K_{rad} , and K_{ax}) are lower in the mixed tumor group and other benign tumors because of the histopathological characteristics of mixed tumors. The tightness and space complexity of the tissue structure, atypia of the nuclei in

organization, and degree of stromal hyperplasia of blood vessels in mixed tumors are lower.

In this study, we used a logistic model with two categories in PAL analysis. One hand, because of the special pathological features of PAL, the identification of PAL and other parotid tumors using conventional DWI technology has great overlap in imaging findings. On the other hand, because of the application of DKI, two analyses of parotid gland disease showed that the DKI parameters had a higher diagnostic capacity for PAL. For example, when the PAL and benign parotid tumors have similar morphological features and TIC curves, the DKI model has a greater ability for differential diagnosis than conventional MRI (Figure 4). Moreover it also has a greater ability for the differential diagnosis between PAL with malignant appearance and malignant parotid tumors (Figure 5). The results of this study showed that the sensitivity and specificity of quantitative parameters of DKI in diagnosis of PAL were higher than conventional MRI.

Figure 3 ROC curve showing the performance of Kax, FA alone, and the combination of these two parameters to differentiate PAL from other tumors of parotid gland. The AUC of FA + Kax [0.881 ± 0.057 (0.824 to 0.938)] was higher than that of Kax [0.800 ± 0.070 (0.730 to 0.870)] and FA alone [0.629 ± 0.095 (0.534 to 0.724)]. AUC, area under the ROC curve; PAL, parotid adenolymphoma; ROC, receiver operating characteristic.

In this experiment, using two Logistic model combined with various parameters can further improve the diagnostic results, the test of the sensitivity and specificity of diagnosis have reached a higher level, indicates that the model has the higher application value in the differential diagnosis of PAL and other PGD. In addition, in order to make this study more valuable for routine clinical diagnosis, nearly all kinds of common diseases of the parotid gland (including tumor and infectious diseases) and normal parotid glands (considered as control group) were included.

There are still some limitations in our study. First, the research period was short, and the number of collected samples was relatively small between the experimental group and control group in the differential diagnosis of PAL, leading to low statistical efficiency. More data need to be collected in the future. Second, because of the lower resolution of the original image of DKI, some errors in both the measurements and the experimental results may be encountered.¹⁸ Third, the non-linear squared fitting method used for DKI parameter computation in this study is susceptible to noise for low signal-to-noise data at high b values. Therefore, an advanced method, such as the multi-step weighted linear least squared (WLLS) approach, which could provide high performance in terms of both accuracy and precision is necessary.¹⁹

Figure 4 Figure 1a–f of a 39-year-old male with PMT and Figure 2a–f of a 54-year-old male with PAL. The diseases were correctly diagnosed using a combination diagnosis with DKI-derived parameters. Both T1 weighted (1A, 2A) and FS-T2 weighted images (1B, 2B) demonstrated the lesion located in the right parotid gland with a smooth margin and sac changed inside. (1C, 2C) TIC curve pattern C. (1D, 2D) A higher signal intensity can be observed in the color-coded DWI map with ADC values of $1.389 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$ and $1.021 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$. (1E, 2E) The color-coded Kax map and the Kurtosis-related parameters of case 1 vs case 2 were as follows: Kmean (0.572 vs 0.842), Krad (0.574 vs 0.838), Kax (0.620 vs 0.875), FA (0.099 vs 0.103). (1F, 2F) Pathological maps. When -0.751 was used as a cut-off value in the combination equation, the Y value (0.545) of case 1 was larger to indicate the diagnosis of PAL, and the Y value (-3.898) of case 2 was lower to indicate the diagnosis of other pathological patterns of PGT. When the averages of DKI-derived parameters were combined, the diagnosis of PMT was implied. Consequently, this result was verified by final pathology. DWI, diffusion-weighted imaging; DKI, diffusion kurtosis imaging; PAL, parotid adenolymphoma; PMT, parotid mixed tumor.

Figure 5 a–e of a 68-year-old male with PAL and a–e of a 53-year-old male with parotid gland squamous cell carcinoma (PGSCC). They were correctly diagnosed by the combination of DKI-derived parameters. Both T1 weighted (3A, 4A) and FS-T2 weighted images (3B, 4B) demonstrated the lesion that located in the right parotid gland (case 3) and left parotid gland (case 4) with an obscure boundary and invasive biological behavior. (3C, 4C) A higher signal intensity can be found in the color-coded DWI map with ADC values of $0.777 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$ and $0.784 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$. (3D, 4D) The color-coded Kax map and kurtosis-related parameters of case 3 vs case 4 were as follows: Kmean (1.029 vs 0.750), Krad (1.091 vs 0.774), Kax (1.246 vs 0.738), and FA (0.128 vs 0.142). (1E, 2E) Pathological maps. When -0.751 was used as a cut-off value in combination diagnosis, the Y value (2.050) of case 3 was larger which indicate the diagnosis of PAL, and the Y value (-4.778) of case 4 was lower which indicate the diagnosis of other pathological patterns of PGT, with the mean values of the DKI-derived parameters considered, the diagnosis of PGSCC was implied. Consequently, this result was confirmed by final pathology. ADC, apparent diffusion coefficient; DKI, diffusion kurtosis imaging; DWI, diffusion-weighted imaging; PAL, parotid adenolymphoma; PGSCC, parotid gland squamous cell carcinoma.

In conclusion, DKI has better performance in diagnosing different pathological types of PGD compared with conventional MRI, and the combined diagnostic parameters of DKI have higher diagnostic ability in the

identification of PAL. This study indicates that DKI has great potential value in the accurate diagnosis of parotid tumors under the conditions of without morphological features.

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